IEA PVPS

Standardized Information Models as a base for Digital Twins

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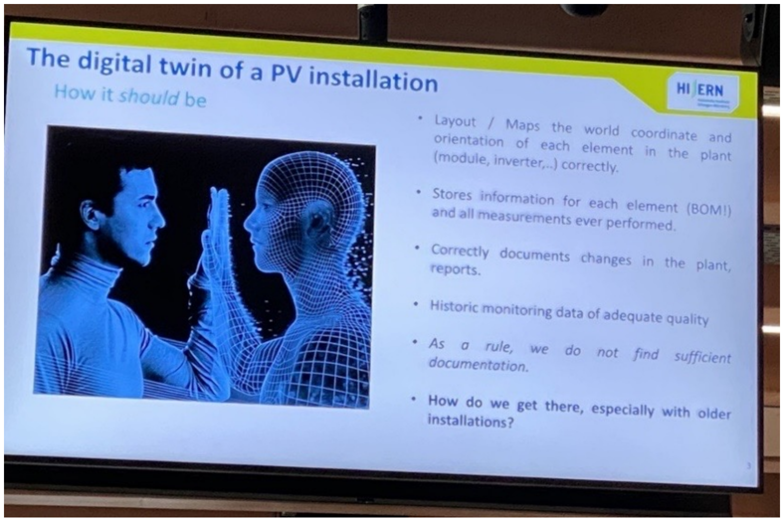
Outline

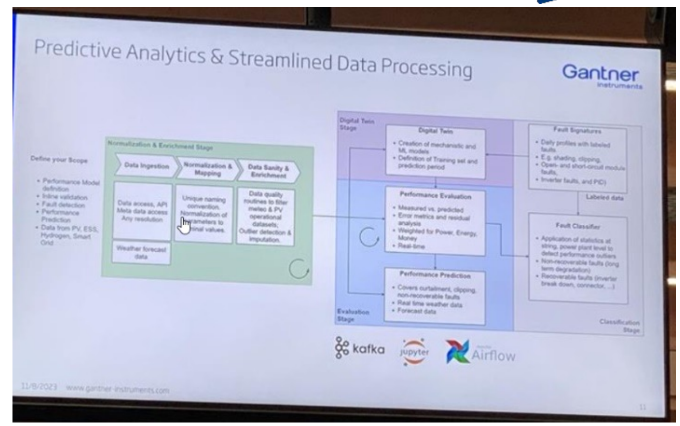
- Digital Twins at PVPMC Nov 2023
- Digital Twin characteristics
- FAIR approach
- Taxonomies, Information Models, Ontologies
- Enriching Digital Twins with Semantics → Interoperability
- European Energy Data Spaces
- Vision: PV Federation of Trust

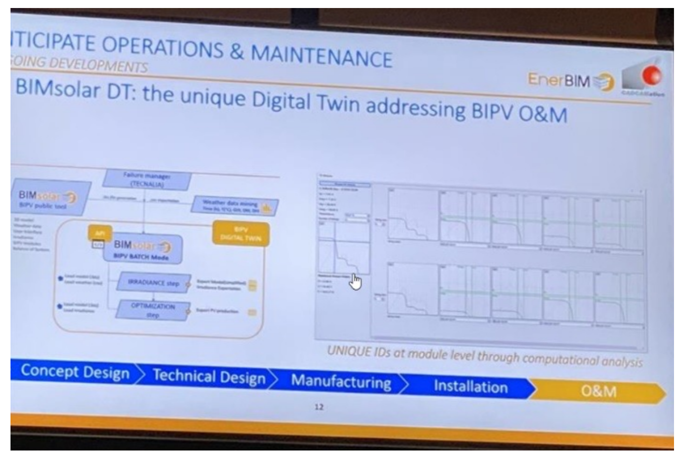
Digital Twins at PVPMC Nov 2023



Collecting datasets of PV power stations for performance analysis Claudia Buerhop Forschungszentrum Jülich GmbH

Data-driven predictive analytics and system monitoring workflows for streamlined utility-scale photovoltaic power plant failure diagnosis, Juergen Sutterlueti Gantner Instruments





BIPV Digital Twin innovations with CADCAMation Philippe Alamy EnerBIM

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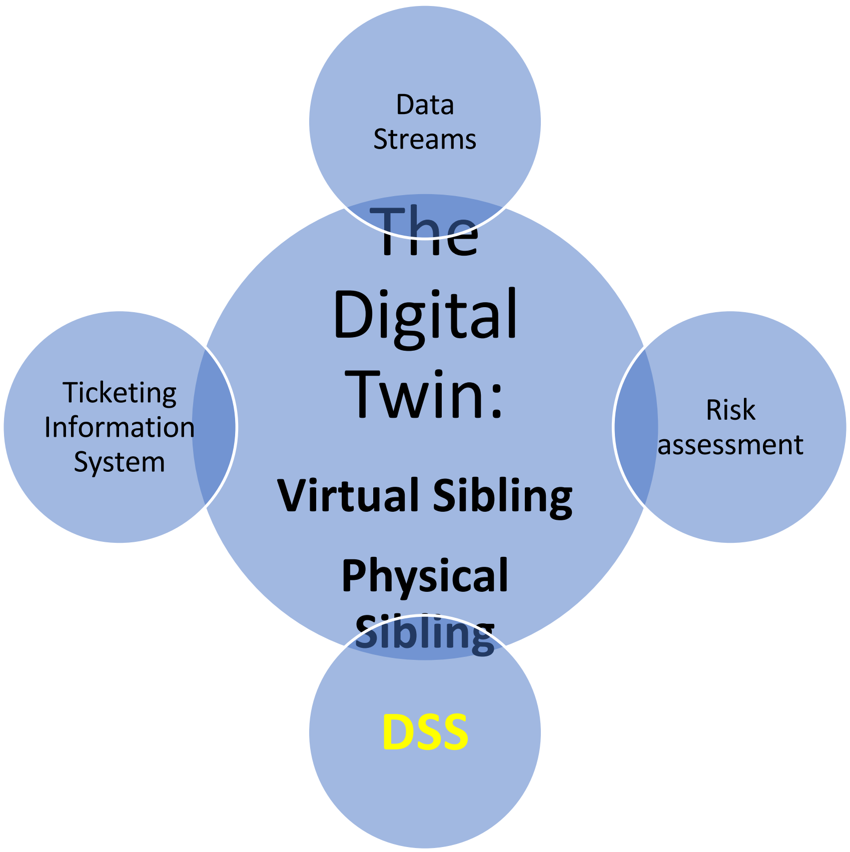
Digital Twins in Photovoltaic Systems



- Enabling technologies:
  - information models, ontology/semantic models for interoperability, RDF
  - → FAIR principle
  - System simulation, phys., ML, AI
  - Monitoring and control of physical representation, IoT devices
  - Data analytics / long term data storage, Data visualization
  - Interfaces to adjacent domains (e.g. GDIs, weather/satellites etc.)

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"A digital twin is a virtual representation of a PV system that spans its lifecycle, is updated from real data, and uses simulation, machine learning and reasoning to help decision making."

"FAIR Principles for scientific data management.." – applied to PV

- Findable: PV data (simulaton and Monitoring), related metadata with persistent identifiers/DOIs/FDOs, → findable and citable (e.g. via CSW)
- Accessible: No Data Silos. PV simulation data and associated services openly accessible, clear instructions on how to access and utilize them.
- Interoperable
  - well-documented metadata that describes the PV simulation data, simulation methodology, input parameters, assumptions.
  - standardized data formats, information models and/or ontologies specific to the Photovoltaic domain to enhance interoperability.
- Reusable: proper data licensing and usage terms to enable reuse and collaboration among researchers and practitioners in the PV field (even beyond the original purpose)

Ontologies, Taxonomies, Information models

Taxonomies

- Hierarchical classification system organizing objects into categories.

Information Models

- Represent data and its structure, typically using entities, attributes, and relationships.
- Focus on capturing data structure and organization.

Ontologies

- Formal representation of knowledge, complex relationships, reasoning capabilities. Domain knowledge, logic-based formalisms

Importance of Information models for DT

- Digital twinning involves creating a virtual representation or replica of a physical object – a PV system
- A standardized (PV-) Information Model represents the data and structure of the object or system being twinned. Consists of Entities, attributes, and relationships that define the digital twin and how it is organized.
- PV Information Model enables data management, analysis, and simulation in the context of digital twinning applications
- Ontologies are also being used in digital twinning, going a step further (machine reasoning)
- Semantics turn data into information
- Interoperability

Importance of Information models for DT

- Let‘s ask a generative AI to „Visualize a standardized information model for digital twins of PV systems“ ☺

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Information Models, Taxonomies, Ontologies in PV

- PVML - Photovoltaic Markup Language: Toward Universal Structure for Collection and Exchange of Data Acquired During PV Monitoring Process. Prorok, M. et al, 2008
- PV-TONS: A photovoltaic technology ontology system for the design of PV-systems, Abanda et al, 2013
- OrangeButton – “open data exchange standard for the distributed solar PV industry”, Hansen et al 2018, SANDIA
- Open Energy Ontology, Booshehri et al 2021
- A Photovoltaic System Model Integrating FAIR Digital Objects and Ontologies, Schweikert et al 2023
- Proposing an Ontology Model for Planning Photovoltaic Systems, Khosrojerdi, 2021

Information Models and ontologies in PV

- CIM (Common Information Model): CIM is an information model standard used in the power system domain, including PV systems. It represents the structure and behavior of PV assets, enabling interoperability and integration with other power system components.
- For BIPV: BIM (Building Information Model), CityGML, IFC
- From OpenGeospatialConsortium (OGC): Sensor Markup Language within Sensor Web Enablement

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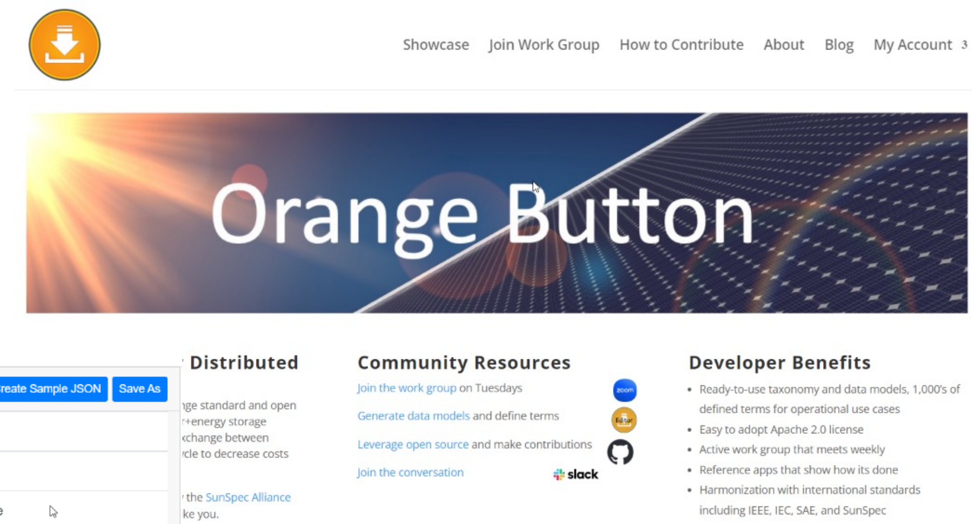
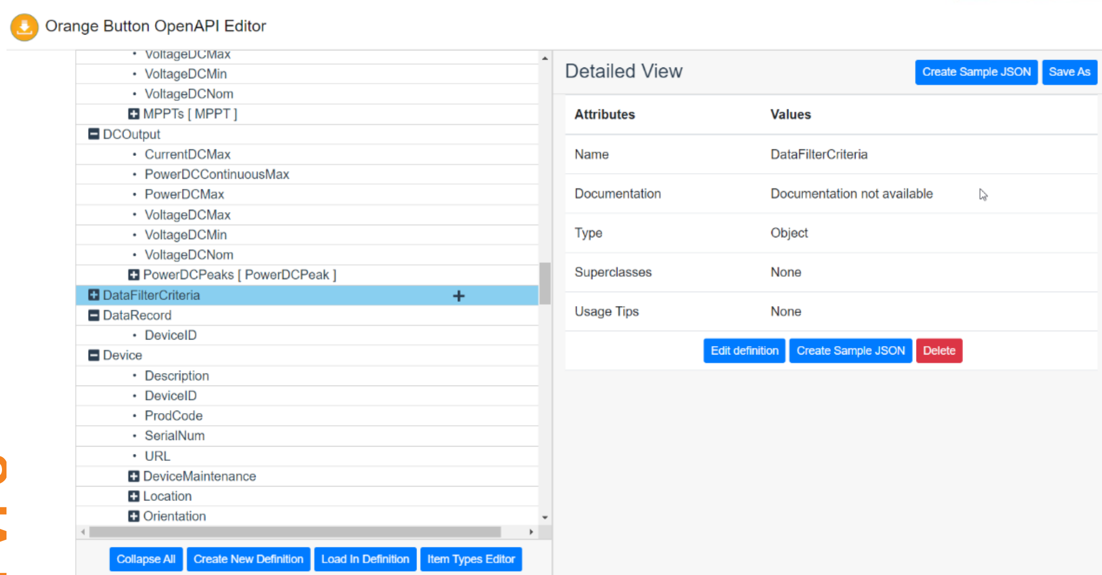
OrangeButton taxonomy and data model

- Introduced to PVPMC in 2018
- How widely used?
- OpenAPI for RESTful services





European Commission: Digitalising the Energy System

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A European framework for sharing data to support innovative energy services

Opportunity / issue: The key enabler for a digitalised energy system is the availability of, access to, and sharing of energy-related data.

Aim: To facilitate the development of innovative energy solutions and novel and inclusive services that will support grid developments, engage consumers/prosumers and lower bills, and further the integration of the energy market.

Means: Develop a European framework for sharing energy data. Establish a **common European data space for energy**.

Approach: Harmonizing the European Data Markets in line with sector-specific legislation.

European Commission

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Rolf Riemenschneider, Head of Sector IoT, European Commission, 2023

Vision: (PV-) Federation of Trust

- Federation of Trust with authentication (e.g. Eduroam, internet2 and GEANT)
- DTs use “Simulation as a service”, e.g. also from agricultural- and other domains (APV, PV+Storage etc.)!
- PV “data as a service”
- Standardized access to information from adjacent domains (geospatial, weather, buildings, forecast etc.) via APIs
- Federated learning within data spaces
- GDPR compliant
- An “End to data silos”

Thank you for your interest!

IEA Task 13 in exchange with IEA Task 15

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